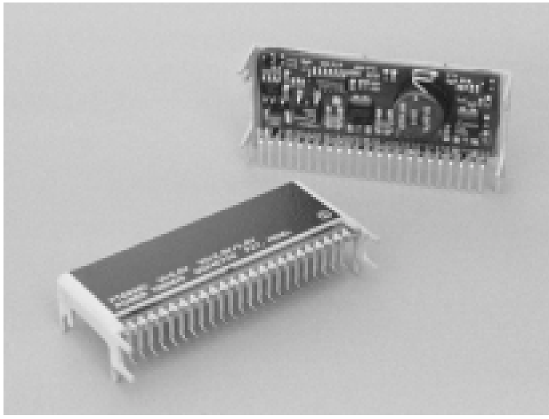
Jameco Part Number 1365722



Features

- Dual Outputs
  (See Ordering Information)
- 5V/3.3V Input
- Outputs Adjustable
- Remote Sensing (Vo_1 & Vo_2)
- Standby Function
- Soft-Start
- Internal Sequencing
- Short Circuit Protection
- 23-pin Space-Saving Package
- Solderable Copper Case
- Ideal Power Source for DSPs

Description

The PT6935 Excalibur™ series of power modules are dual output integrated switching regulators (ISRs) designed to power the latest mixed signal ICs. The dual output provides power for both the digital I/O logic and a DSP core from a single module. Both output voltages are internally sequenced during power-up and power-down to comply with the requirements of the latest DSP chips. Each output is independently adjustable or can be set to at least one alternative bus voltage with a simple pin-strap. The modules are made available in a space-saving solderable case. Features include an output current limit and short-circuit protection.

Ordering Information

PT6935❑ = +2.5/1.8 Volts
PT6936❑ = +3.3/2.5 Volts
PT6937❑ = +3.3/1.8 Volts
PT6938❑ = +3.3/1.2 Volts
PT6939❑ = +2.5/1.2 Volts

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code
Vertical	N	(ELF)
Horizontal	A	(ELG)
SMD	C	(ELH)

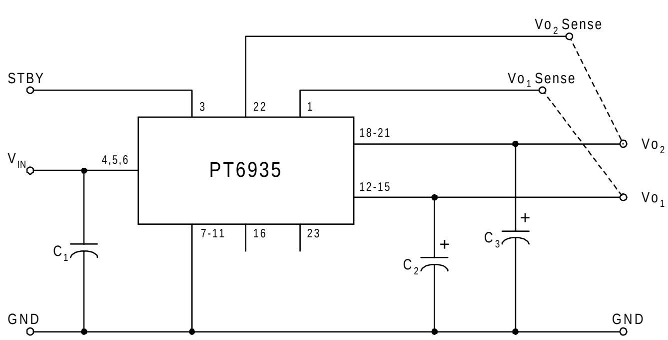
(Reference the applicable package code drawing for the dimensions and PC layout)

Pin-Out Information

Pin	Function	Pin	Function
1	Vo_1 Sense	13	Vo_1
2	No Connect	14	Vo_1
3	STBY	15	Vo_1
4	V_{in}	16	Vo_1 Adjust*
5	V_{in}	17	No Connect
6	V_{in}	18	Vo_2
7	GND	19	Vo_2
8	GND	20	Vo_2
9	GND	21	Vo_2
10	GND	22	Vo_2 Sense
11	GND	23	Vo_2 Adjust*
12	Vo_1		

* *Vo_1 and Vo_2 can be pin-strapped to another voltage. See application note on output voltage adjustment.*

Standard Application



C_1 = Req'd 330µF * electrolytic
C_2 = Req'd 330µF * electrolytic
C_3 = Optional 100µF electrolytic

* 300µF for Oscon® or low ESR tantalum -see notes

General Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V)

Characteristic	Symbol	Conditions	PT6935 Series Min	Typ	Max	Units
Short Circuit Current	I_{sc}	$Io_1 + Io_2$ combined	—	17	—	A
Switching Frequency	f_o	Over V_{in} range	300	350	400	kHz
Standby (Pin 3)		Referenced to GND (pin 7)				
Input High Voltage	V_{IH}		—	—	Open (1)	V
Input Low Voltage	V_{IL}		–0.1	—	+0.4	
Input Low Current	I_{IL}		—	-0.5	–	mA
Standby Input Current	I_{in} standby	pin 3 to GND	—	7	25	mA
External Output Capacitance	C_2		330 (2)	—	3,300 (2)	µF
	C_3		0	—	330	
Maximum Operating Temperature Range	T_a	Over V_{in} Range	–40 (3)	—	+85 (4)	°C
Storage Temperature	T_s	—	–40	—	+125	°C
Mechanical Shock		Per Mil-STD-883D, Method 2002.3 1 msec, ½ Sine, mounted	—	500	—	G's
Mechanical Vibration		Per Mil-STD-883D, Method 2007.2 20-2000 Hz, Soldered in a PC board	—	15 (5)	—	G's
Weight	—	Vertical/Horizontal	—	26	—	grams
Flammability	—	Meets UL 94V-O				

Notes: *(1) The Standby (pin 3) has an internal pull-up, and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is less than 15V. Refer to the application notes for interface considerations.*
(2) A value of 300µF is sufficient if Oscon® or low ESR tantalum type capacitors are used. The total combined ESR of all output capacitance at 100kHz must be (greater than) >12 mΩ, and (less or equal to) ≤150mΩ.
(3) For operating temperatures below 0°C, Cin and Cout must have stable characteristics. Use either tantalum or Oscon® capacitors.
(4) See Safe Operating Area curves for the specific output voltage combination, or contact the factory for the appropriate derating.
(5) Only the case pins on through-hole pin configurations (N & A) must be soldered. For more information see the applicable package outline drawing.

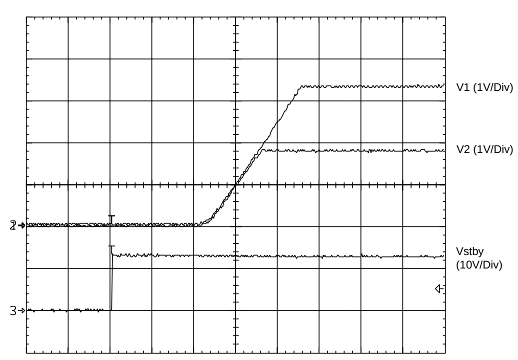
Input/Output Capacitors: *The PT6935 series requires a 330µF electrolytic capacitor at both the input and output for proper operation (300µF for Oscon® or low ESR tantalum). In addition, the input capacitance must be rated for a minimum of 1.0Arms ripple current. For transient or dynamic load applications, additional capacitance may be required. Refer to the application notes for more information.*

Power-up Sequencing and Vo_1/Vo_2 Loading

Power-up Sequencing

The PT6935 series of regulators provide two output voltages, Vo_1 and Vo_2. Each of the output voltage combinations offered by the PT6935 series provides power for both a low-voltage processor core, and the associated digital support circuitry. In addition, each output is internally sequenced during power-up and power-down to comply with the requirements of most DSP and µP IC's, and their accompanying chipsets. Figure 1 shows the typical waveforms of the output voltages, Vo_1 and Vo_2, from the instance that either input power is applied or the module is enabled via the Standby pin. Following a delay of about 10 to 15 milli-secs, the voltages at Vo_1 and Vo_2 rise together until Vo_2 reaches its set-point. Then Vo_1 continues to rise until both output voltages have reached full voltage.

Figure 1; PT6935 Series Power-up



Vo_1/Vo_2 Loading

The output voltages from the PT6935 series regulators are independently regulated. The voltage at Vo_1 is produced by a highly efficient switching regulator. The lower output voltage, Vo_2, is derived from Vo_1. The regulation method used for Vo_2 also provides control of this output voltage during power-down. Vo_2 will sink current if the voltage at Vo_1 attempts to fall below it.

The load specifications for each model of the PT6935 series gives both a 'Typical' (Typ) and 'Maximum' (Max) load current for each output. For operation within the product's rating, the load currents at Vo_1 and Vo_2 must comply with the following limits:-

- Io_2 must be less than Io_2(max).
- The sum-total current from both outputs ($Io_1 + Io_2$) must not exceed Io_1(max).

In the case that either Vo_1 or Vo_2 are adjusted to some other value than the default output voltage, the absolute maximum load current for Io_2 must be revised to comply with the following equation.

$$Io_2\ (max) = \frac{2.5}{Vo_1 - Vo_2} \quad Adc$$

Consult the specification table for each model of the series for the actual numeric values.

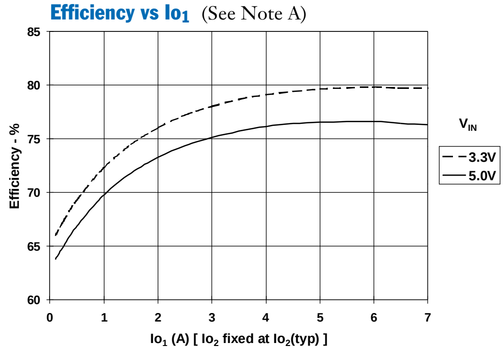
PT6935 Performance Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V, C_1 =330µF, C_2 =330µF, Io_1 =Io_1typ, and Io_2 =Io_2typ)

Characteristic	Symbol	Conditions		PT6935 (2.5V/1.8V) Min	Typ	Max	Units
Output Current	Io_1 Io_2	T_a =25°C, natural convection	Vo_1 (2.5V) Vo_2 (1.8V)	0.1 (i) 0	7 (ii) 2.5 (ii)	9.5 (iii) 3.5 (iii)	A
	Io_1 Io_2	T_a =60°C, 200LFM airflow	Vo_1 (2.5V) Vo_2 (1.8V)	0.1 (i) 0	7 (ii) 2.5 (ii)	10 (iii) 3.5 (iii)	A
Input Voltage Range	V_{in}	Over I_o Range		3.1	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol		Vo_1 Vo_2	— —	±12 ±9	±38 ±27	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	Vo_1 Vo_2	— —	±5 ±2	±10 ±5	mV
Load Regulation	Reg_{load}	Over I_o range	Vo_1 Vo_2	— —	±5 ±5	±10 ±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C	Vo_1 Vo_2	— —	±34 ±25	— —	mV
Efficiency	η			—	79	—	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	Vo_1 Vo_2	— —	35 35	— —	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$typ		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot	Vo_1 Vo_2	— —	±60 ±60	— —	mV

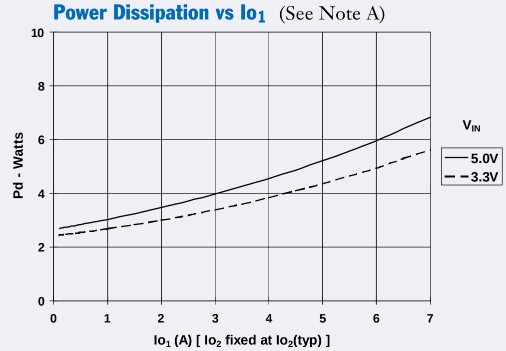
Notes: *(i) Io_1(min) current of 0.1A can be divided between both outputs, Vo_1 or Vo_2. The module will operate at no load with reduced specifications.*
(ii) The typical current is that which can be drawn simultaneously from both outputs under the stated operating conditions.
(iii) The sum of Io_1 and Io_2 must be less than Io_1max, and Io_2 must be less than Io_2max.

PT6935 Typical Characteristics

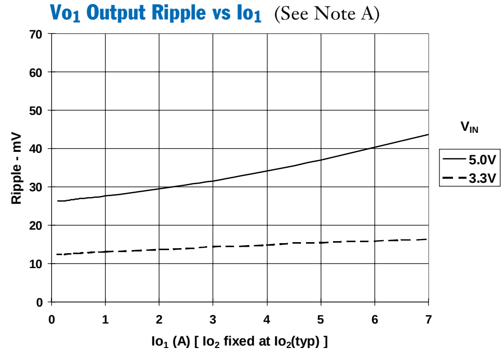
Efficiency vs Io_1 (See Note A)



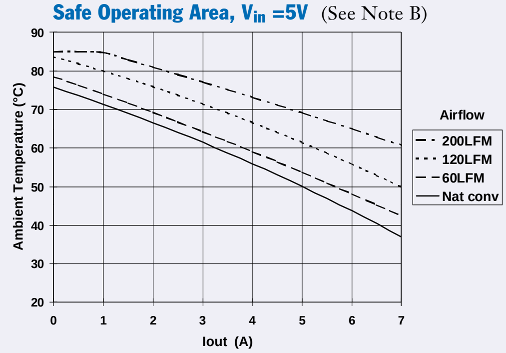
Power Dissipation vs Io_1 (See Note A)



Vo_1 Output Ripple vs Io_1 (See Note A)



Safe Operating Area, V_{in} =5V (See Note B)



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

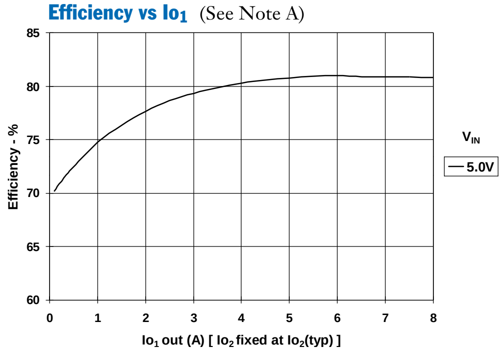
PT6936 Performance Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V, C_1 =330µF, C_2 =330µF, Io_1 =Io_1typ, and Io_2 =Io_2typ)

Characteristic	Symbol	Conditions		PT6936 (3.3V/2.5V) Min	Typ	Max	Units
Output Current	Io_1 Io_2	T_a=25°C, natural convection	Vo_1 (3.3V) Vo_2 (2.5V)	0.1 (i) 0	8 (ii) 3 (ii)	11 (iii) 3 (iii)	A
	Io_1 Io_2	T_a =60°C, 200LFM airflow	Vo_1 (3.3V) Vo_2 (2.5V)	0.1 (i) 0	8 (ii) 3 (ii)	11 (iii) 3 (iii)	A
Input Voltage Range	V_{in}	Over I_o Range		4.5	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol		Vo_1 Vo_2	— —	±16 ±12	±50 ±38	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	Vo_1 Vo_2	— —	±5 ±2	±10 ±5	mV
Load Regulation	Reg_{load}	Over I_o range	Vo_1 Vo_2	— —	±5 ±5	±10 ±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C	Vo_1 Vo_2	— —	±29 ±34	— —	mV
Efficiency	η			—	81	—	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	Vo_1 Vo_2	— —	35 35	— —	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$typ		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot	Vo_1 Vo_2	— —	±60 ±60	— —	mV

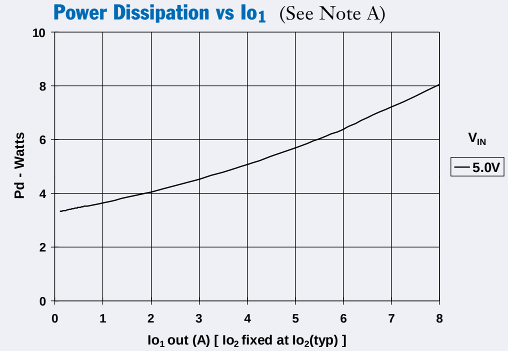
Notes: *(i) Io_1(min) current of 0.1A can be divided between both outputs, Vo_1 or Vo_2. The module will operate at no load with reduced specifications.*
(ii) The typical current is that which can be drawn simultaneously from both outputs under the stated operating conditions.
(iii) The sum of Io_1 and Io_2 must be less than Io_1max, and Io_2 must be less than Io_2max.

PT6936 Typical Characteristics

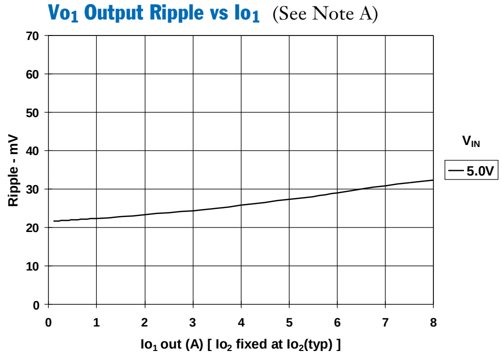
Efficiency vs Io_1 (See Note A)



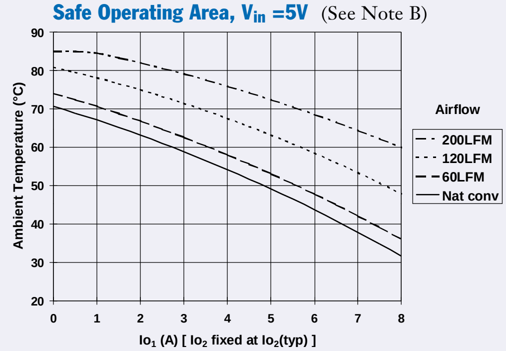
Power Dissipation vs Io_1 (See Note A)



Vo_1 Output Ripple vs Io_1 (See Note A)



Safe Operating Area, V_{in} =5V (See Note B)



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

PT6937 Performance Specifications

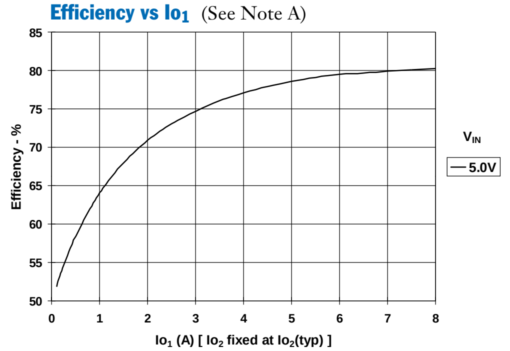
(Unless otherwise stated, T_a =25°C, V_{in} =5V, C_1 =330µF, C_2 =330µF, Io_1 =Io_1typ, and Io_2 =Io_2typ)

Characteristic	Symbol	Conditions		PT6937 (3.3V/1.8V) Min	Typ	Max	Units
Output Current	Io_1 Io_2	T_a =25°C, natural convection	Vo_1 (3.3V) Vo_2 (1.8V)	0.1 (i) 0	8 (ii) 2 (ii)	10 (iii) 2.25 (iii)	A
	Io_1 Io_2	T_a =60°C, 200LFM airflow	Vo_1 (3.3V) Vo_2 (1.8V)	0.1 (i) 0	8 (ii) 2 (ii)	10 (iii) 2.25 (iii)	A
Input Voltage Range	V_{in}	Over I_o Range		4.5	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol		Vo_1 Vo_2	— —	±16 ±9	±50 ±27	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	Vo_1 Vo_2	— —	±5 ±2	±10 ±5	mV
Load Regulation	Reg_{load}	Over I_o range	Vo_1 Vo_2	— —	±5 ±5	±10 ±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C	Vo_1 Vo_2	— —	±29 ±25	— —	mV
Efficiency	η			—	81	—	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	Vo_1 Vo_2	— —	35 35	— —	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$typ		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot	Vo_1 Vo_2	— —	±60 ±60	— —	mV

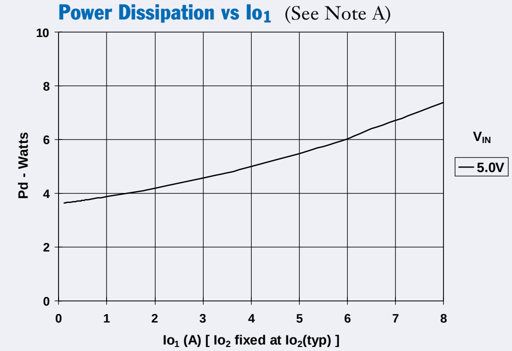
Notes: *(i)* *Io_1(min) current of 0.1A can be divided between both outputs, Vo_1 or Vo_2. The module will operate at no load with reduced specifications.*
(ii) *The typical current is that which can be drawn simultaneously from both outputs under the stated operating conditions.*
(iii) *The sum of Io_1 and Io_2 must be less than Io_1max, and Io_2 must be less than Io_2max.*

PT6937 Typical Characteristics

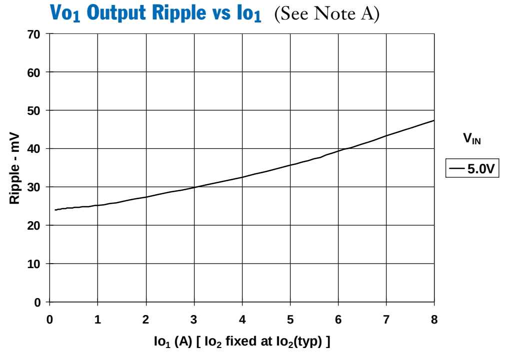
Efficiency vs Io_1 (See Note A)



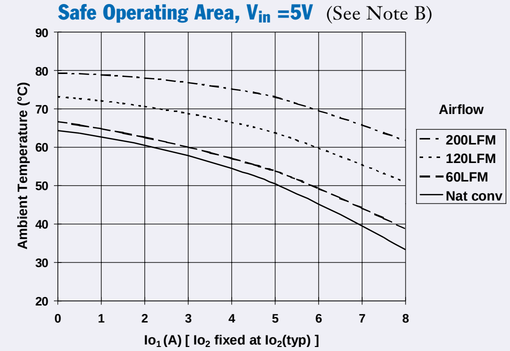
Power Dissipation vs Io_1 (See Note A)



Vo_1 Output Ripple vs Io_1 (See Note A)



Safe Operating Area, V_{in} =5V (See Note B)



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

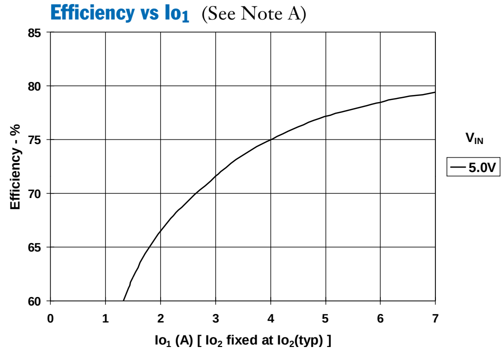
PT6938 Performance Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V, C_1 =330µF, C_2 =330µF, Io_1 =Io_1typ, and Io_2 =Io_2typ)

Characteristic	Symbol	Conditions		PT6938 (3.3V/1.2V) Min	Typ	Max	Units
Output Current	Io_1 Io_2	T_a =25°C, natural convection	Vo_1 (3.3V) Vo_2 (1.2V)	0.1 (i) 0	7 (ii) 1.6 (ii)	8.6 (iii) 1.6 (iii)	A
	Io_1 Io_2	T_a =60°C, 200LFM airflow	Vo_1 (3.3V) Vo_2 (1.2V)	0.1 (i) 0	7 (ii) 1.6 (ii)	8.6 (iii) 1.6 (iii)	A
Input Voltage Range	V_{in}	Over I_o Range		4.5	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol		Vo_1 Vo_2	— —	±16 ±6	±50 ±18	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	Vo_1 Vo_2	— —	±5 ±2	±10 ±5	mV
Load Regulation	Reg_{load}	Over I_o range	Vo_1 Vo_2	— —	±5 ±5	±10 ±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C	Vo_1 Vo_2	— —	±29 ±19	— —	mV
Efficiency	η			—	79	—	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	Vo_1 Vo_2	— —	35 35	— —	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$typ		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot	Vo_1 Vo_2	— —	±60 ±60	— —	mV

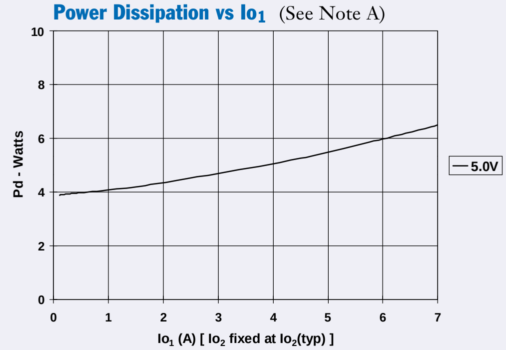
Notes: *(i) Io_1(min) current of 0.1A can be divided between both outputs, Vo_1 or Vo_2. The module will operate at no load with reduced specifications.*
(ii) The typical current is that which can be drawn simultaneously from both outputs under the stated operating conditions.
(iii) The sum of Io_1 and Io_2 must be less than Io_1max, and Io_2 must be less than Io_2max.

PT6938 Typical Characteristics

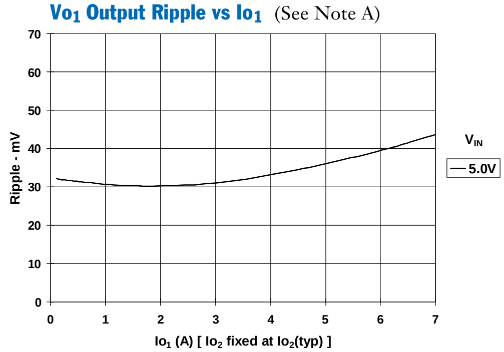
Efficiency vs Io_1 (See Note A)



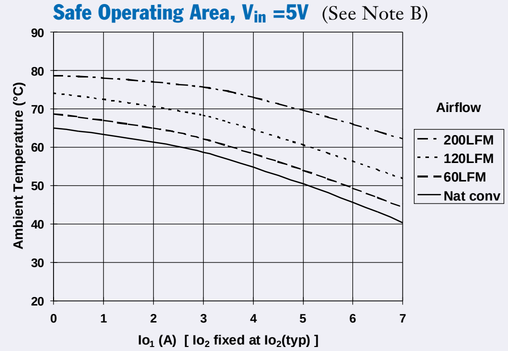
Power Dissipation vs Io_1 (See Note A)



Vo_1 Output Ripple vs Io_1 (See Note A)



Safe Operating Area, V_{in} =5V (See Note B)



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

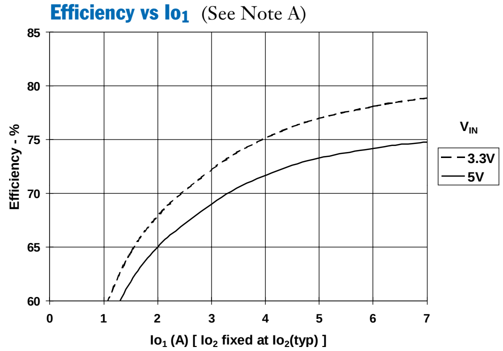
PT6939 Performance Specifications (Unless otherwise stated, T_a =25°C, V_{in} =5V, C_1 =330µF, C_2 =330µF, Io_1 =Io_1typ, and Io_2 =Io_2typ)

Characteristic	Symbol	Conditions		Min	Typ	Max	Units
				PT6939 (2.5V/1.2V)			
Output Current	Io_1 Io_2	T_a =25°C, natural convection	Vo_1 (2.5V) Vo_2 (1.2V)	0.1 (i) 0	7 (ii) 2 (ii)	9 (iii) 2.2 (iii)	A
	Io_1 Io_2	T_a =60°C, 200LFM airflow	Vo_1 (2.5V) Vo_2 (1.2V)	0.1 (i) 0	7 (ii) 2 (ii)	9 (iii) 2.2 (iii)	A
Input Voltage Range	V_{in}	Over I_o Range		3.1	—	5.5	VDC
Set Point Voltage Tolerance	V_o tol		Vo_1 Vo_2	— —	±12 ±6	±38 ±18	mV
Temperature Variation	Reg_{temp}	–40° >T_a > +85°C		—	±0.5	—	%V_o
Line Regulation	Reg_{line}	Over V_{in} range	Vo_1 Vo_2	— —	±5 ±2	±10 ±5	mV
Load Regulation	Reg_{load}	Over I_o range	Vo_1 Vo_2	— —	±5 ±5	±10 ±10	mV
Total Output Voltage Variation	ΔV_otot	Includes set-point, line, load, –40° >T_a > +85°C	Vo_1 Vo_2	— —	±34 ±19	— —	mV
Efficiency	η			—	75	—	%
V_o Ripple (pk-pk)	V_r	20MHz bandwidth	Vo_1 Vo_2	— —	35 35	— —	mV_{pp}
Transient Response	t_{tr}	1A/µs load step, 50% to 100% $I_o$typ		—	60	—	µs
	ΔV_{tr}	V_o over/undershoot	Vo_1 Vo_2	— —	±60 ±60	— —	mV

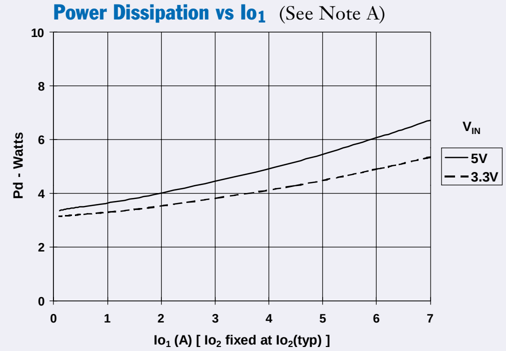
Notes: *(i) Io_1(min) current of 0.1A can be divided between both outputs, Vo_1 or Vo_2. The module will operate at no load with reduced specifications.*
(ii) The typical current is that which can be drawn simultaneously from both outputs under the stated operating conditions.
(iii) The sum of Io_1 and Io_2 must be less than Io_1max, and Io_2 must be less than Io_2max.

PT6939 Typical Characteristics

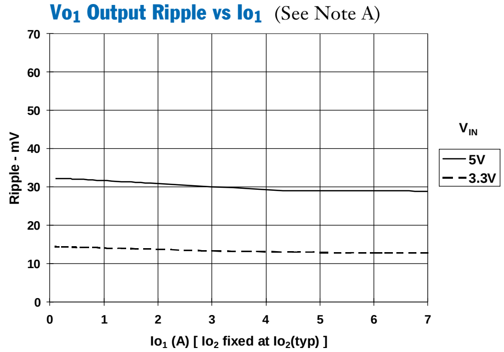
Efficiency vs Io_1 (See Note A)



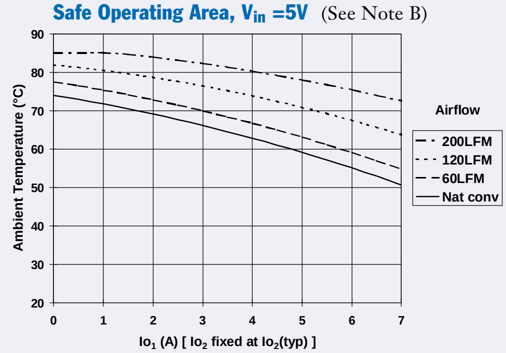
Power Dissipation vs Io_1 (See Note A)



Vo_1 Output Ripple vs Io_1 (See Note A)



Safe Operating Area, V_{in} =5V (See Note B)



Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*
Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

Capacitor Recommendations for the Dual-Output PT6935 Regulator Series

Input Capacitors:

The recommended input capacitance is determined by 1.0 ampere minimum ripple current rating and 330µF minimum capacitance (300µF for Oscon® or low ESR tantalum). Ripple current and <100mΩ equivalent series resistance (ESR) values are the major considerations, along with temperature, when designing with different types of capacitors. Tantalum capacitors have a recommended minimum voltage rating of 2 × the maximum DC voltage + AC ripple. This is necessary to insure reliability for input voltage bus applications

Output Capacitors: C_2(Required), C_3(Optional)

The ESR of the required capacitor (C_2) must not be greater than 150mΩ. Electrolytic capacitors have poor ripple performance at frequencies greater than 400kHz but excellent low frequency transient response. Above the ripple frequency, ceramic capacitors are necessary to improve the transient response and reduce any high frequency noise components apparent during higher current excursions. Preferred low ESR type capacitor part numbers are identified in Table 1. The optional 100µF capacitor (C_3) for V_2out can have an ESR of up to 200mΩ for optimum performance and ripple reduction. *(Note: Vendor part numbers for the optional capacitor, C_3, are not identified in the table. Use the same series selected for C_2)*

Tantalum Capacitors

Tantalum type capacitors can be used for the output but only the AVX TPS series, Sprague 593D/594/595 series or Kemet T495/T510 series. These capacitors are recommended over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution the TAJ series by AVX is not recommended. This series has considerably higher ESR, reduced power dissipation, and lower ripple current capability. The TAJ series is less reliable than the AVX TPS series when determining power dissipation capability. Tantalum or Oscon® types are recommended for applications where ambient temperatures fall below 0°C.

Capacitor Table

Table 1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The number of capacitors required at both the input and output buses is identified for each capacitor type.

This is not an extensive capacitor list. Capacitors from other vendors are available with comparable specifications. Those listed are for guidance. The RMS ripple current rating and ESR (Equivalent Series Resistance at 100kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.

Table 1: Input/Output Capacitors

Capacitor Vendor/ Component Series	Capacitor Characteristics					Quantity		
	Working Voltage	Value(µF)	(ESR) Equivalent Series Resistance	85°C Maximum Ripple Current(Irms)	Physical Size(mm)	Input Bus	Output Bus	Vendor Number
Panasonic FC	25V 35V 35V	560µF 390µF 330µF	0.0065Ω 0.065Ω 0.117Ω	1205mA 1205mA 555mA	12.5x15 12.5x15 8x11.5	1 2 N/R	1 1 1	EEUFC1E561S EEUFC1V391S EEUFC1C331
United Chemi-Con LXV/FS/ LXZ	16V 35V 10V 20V	330µF 470µF 330µF 150µF	0.120Ω 0.052Ω 0.025Ω 0.030÷2 Ω	555mA 1220mA 3500mA 3200mA	8x12 10x20 10x10.5 10x10.5	N/R 1 1 2	1 1 1 2	LXZ16VB331M8X12LL LXZ35VB471M10X20LL 10FS330M 20FS150M
Nichicon PL/ PM	35V 35V 50V	560µF 330µF 470µF	0.048Ω 0.065÷2 Ω 0.046Ω	1360mA 1020mA 1470mA	16x15 12.5x15 18x15	1 1 1	1 1 1	UPL1V561MHH6 UPL1V331MHH6 UPM1H4711MHH6
Panasonic FC (Surface Mtg)	10V 35V 16V	1000µF 330µF 330µF	0.043Ω 0.065Ω 0.150Ω	1205mA 1205mA 670mA	12x16.5 12.5x16 10x10.2	1 1 N/R	1 1 1	EEVFC1A102LQ EEVFC1V331LQ EEVFC1C331P
Oscon- SS SV	10V 10V 20V	330µF 330µF 150µF	0.025Ω 0.025Ω 0.024÷2 Ω	>3500mA >3800mA 3600mA	10.0x10.5 10.3x10.3 10.3x10.3	1 1 2	1 1 2	10SS330M 10SV300M 20SV150M SV= Surface Mount
AVX Tantalum TPS	10V 10V 10V	330µF 330µF 220µF	0.100÷2 Ω 0.100÷2 Ω 0.095Ω	>2500mA >3000mA >2000mA	7.3Lx 4.3Wx 4.1H	2 2 2	1 1 2	TPSV337M010R0100 TPSV337M010R0060 TPSV227M0105R0100
Kemet T510/ T495	10V 10V	330µF 220µF	0.033Ω 0.07Ω÷2 =0.035Ω	1400mA >2000mA	7.3Lx5.7W x 4.0H	2 2	1 2	T510X337M010AS T495X227M010AS
Sprague 594D	10V 10V	330µF 220µF	0.045Ω 0.065Ω	2350mA >2000mA	7.3Lx 6.0Wx 4.1H	2 2	1 2	4D337X0010R2T 594D227X0010D2T

N/R –Not recommended. The voltage rating does not meet the minimum operating limits.

Adjusting the Output Voltage of the PT6935 Dual Output Voltage ISRs

Each output voltage from the PT6935 series of ISRs can be independantly adjusted higher or lower than the factory trimmed pre-set voltage. The voltages, Vo_1 and Vo_2 may each be adjusted either up or down using a single external resistor [1]. Table 1 gives the adjustment range for both Vo_1 and Vo_2 for each model in the series as V_a(min) and V_a(max). Note that Vo_2 must always be lower than Vo_1 [2].

Vo_1 Adjust Up: To increase the output, add a resistor R4 between pin 16 (V_1 Adjust) and pins 7-11 (GND) [1].

Vo_1 Adjust Down: Add a resistor (R3), between pin 16 (Vo_1 Adjust) and pin 1 (Vo_1 Sense) [1].

Vo_2 Adjust Up: Add a resistor R2 between pin 23 (Vo_2 Adjust) and pins 7-11 (GND) [1].

Vo_2 Adjust Down: Add a resistor (R1) between pin 23 (Vo_2 Adjust) and pin 22 (Vo_2 Sense) [1].

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor.

Notes:

1. Use only a single 1% resistor in either the (R3) or R4 location to adjust Vo_1, and in the (R1) or R2 location to adjust Vo_2. Place the resistor as close to the ISR as possible.
2. Vo_2 must always be at least 0.2V lower than Vo_1.
3. Both the Vo_1 and Vo_2 may be adjusted down to an alternative bus voltage by making, (R3) or (R1) respectively, a zero ohm link. Refer to the Table 1 footnotes for guidance.
4. Adjusting the Vo_1 output voltage of either the PT6935 (2.5V/1.8V model) or PT6939 (2.5V/1.2V) higher than the factory pre-trimmed output voltage, may increase the minimum input voltage specified for the part. These models must comply with the following requirements.

   PT6935/PT6939:

   $V_{in}(min) = (V_a + 0.6)V$ or 3.1V, whichever is greater.

5. Never connect capacitors to either the Vo_1 Adjust or Vo_2 Adjust pins. Any capacitance added to these control pins will affect the stability of the respective regulated output.
6. Adjusting either voltage (Vo_1 or Vo_2) may increase the power dissipation in the regulator, and change the maximum current available at either output. Consult the note on p.2 of the data sheet regarding Vo_1/Vo_2 loading.

The adjust up and adjust down resistor values can also be calculated using the following formulas. Be sure to select the correct formula parameter from Table 1 for the output and model being adjusted.

$$(R_1) \text{ or } (R_3) = \frac{10\,(V_a - V_r)}{V_o - V_a} - R_s \quad k\Omega$$

$$(R_2) \text{ or } (R_4) = \frac{10 \cdot V_r}{V_a - V_o} - R_s \quad k\Omega$$

Where: V_o = Original output voltage, (Vo_1 or Vo_2)
V_a = Adjusted output voltage
V_r = The reference voltage from Table 1
R_s = The series resistance from Table 1

Figure 1

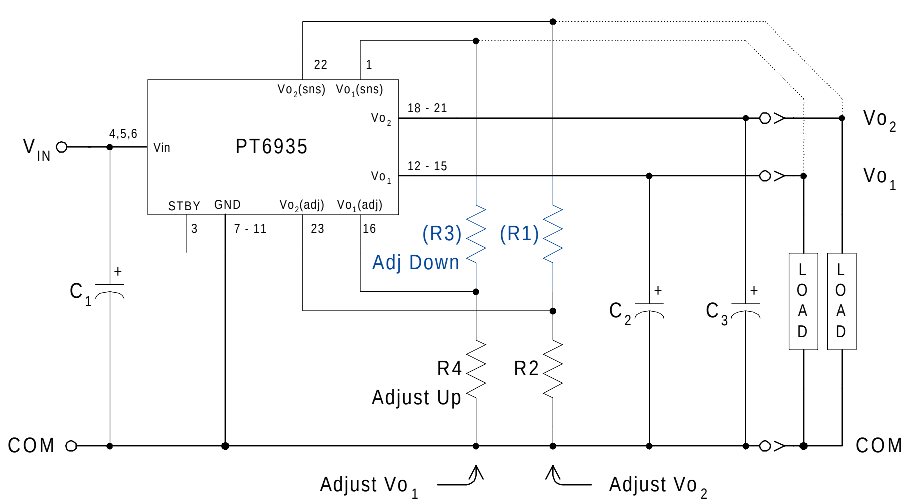


Table 1

ADJUSTMENT RANGE AND FORMULA PARAMETERS

Vo1 Bus			**Vo2 Bus (2)**		
Series Pt #	**PT6935/39**	**PT6936/37/38**	**PT6938/39**	**PT6935/37**	**PT6936**
Adj. Resistor	**(R3)/R4**	**(R3)/R4**	**(R1)/R2**	**(R1)/R2**	**(R1)/R2**
V_o(nom)	2.5V	3.3V	1.2V	1.8V	2.5V
Va(min)	1.8V *	2.5V *	1.0V †	1.5V †	1.8V †
Va(max)	3.6V (4)	3.6V	1.5V #	2.4V	3.0
Vr	1.27V	1.27V	0.6125V	1.0V	1.0V
R_s (kΩ)	7.5	15.4	20.0	16.9	11.5

Ref. Note 3: * (R3) = Zero-ohm link
†(R1) = Zero-ohm link
(R2) = Zero-ohm link

Table 2

ADJUSTMENT RESISTOR VALUES

Vo1 Bus

Series Pt #	**PT6935/39**	**PT6936/37/38**
Adj. Resistor	**(R3)/R4**	**(R3)/R4**
V_o(nom)	2.5V	3.3V
V_a(req'd)		
1.8	(0.0)	
1.85	(1.4)kΩ	
1.9	(3.0)kΩ	
1.95	(4.9)kΩ	
2.0	(7.1)kΩ	
2.05	(9.8)kΩ	
2.1	(13.3)kΩ	
2.2	(23.5)kΩ	
2.3	(44.0)kΩ	
2.4	(106.0)kΩ	
2.5		(0.0)kΩ
2.6	120.0kΩ	(3.6)kΩ
2.7	56.0kΩ	(8.4)kΩ
2.8	34.8kΩ	(15.2)kΩ
2.9	24.3kΩ	(25.4)kΩ
3.0	17.9kΩ	(42.3)kΩ
3.1	13.7kΩ	(76.1)kΩ
3.2	10.6kΩ	(178.0)kΩ
3.3	8.4kΩ	
3.4	6.6kΩ	112.0k
3.5	5.2kΩ	48.1k
3.6	4.1kΩ	26.9k

Vo2 Bus

Series Pt #	**PT6938/39**	**PT6935/37**	**PT6936**
Adj. Resistor	**(R1)/R2**	**(R1)/R2**	**(R1)/R2**
V_o(nom)	1.2V	1.8V	2.5V
V_a(req'd)			
1.0	(0.0)kΩ		
1.05	(9.2)kΩ		
1.1	(28.8)kΩ		
1.15	(87.5)kΩ		
1.2			
1.25	101.5kΩ		
1.3	41.2kΩ		
1.35	20.8kΩ		
1.4	10.6kΩ		
1.45	4.5kΩ		
1.5	0.0kΩ	(0.0)kΩ	
1.55		(5.1)kΩ	
1.6		(13.1)kΩ	
1.65		(26.4)kΩ	
1.7		(53.1)kΩ	
1.75		(133.0)kΩ	
1.8			(0.0)kΩ
1.85		183.0kΩ	(1.6)kΩ
1.9		83.1kΩ	(3.5)kΩ
1.95		49.8kΩ	(5.8)kΩ
2.0		33.1kΩ	(8.5)kΩ
2.05		23.1kΩ	(11.8)kΩ
2.1		16.4kΩ	(16.0)kΩ
2.2		8.1kΩ	(28.5)kΩ
2.3		3.1kΩ	(53.5)kΩ
2.4		0.0kΩ	(129.0)kΩ
2.5			
2.6			88.5kΩ
2.7			38.5kΩ
2.8			21.8kΩ
2.9			13.5kΩ
3.0			8.5kΩ

R_1/R_3 = (Blue), R_2/R_4 = Black

Using the Standby Function on the PT6935 Series of Dual-Output Voltage Regulators

Both output voltages of the 23-pin PT6935 dual-output converter may be disabled using the regulator's 'Standby' function. This function may be used in applications that require power-up/shutdown sequencing, or wherever there is a requirement to control the output voltage On/Off status with external circuitry.

The standby function is provided by the *STBY** control (pin 3). If pin 3 is left open-circuit the regulator operates normally, and provides a regulated output at both Vo_1 (pins 12–15) and Vo_2 (pins 18–21) whenever a valid supply voltage is applied to V_{in} (pins 4, 5, & 6) with respect to GND (pins 7-11). If a low voltage[1] is then applied to pin-3 both regulator outputs will be simultaneously disabled and the input current drawn by the ISR will drop to a typical value of 7mA. The standby control may also be used to hold-off both regulator outputs during the period that input power is applied.

The standby pin is ideally controlled using an open-collector (or open-drain) discrete transistor (See Figure 1). The open-circuit voltage is typically 12.6V. Table 1 gives the circuit parameters for this control input.

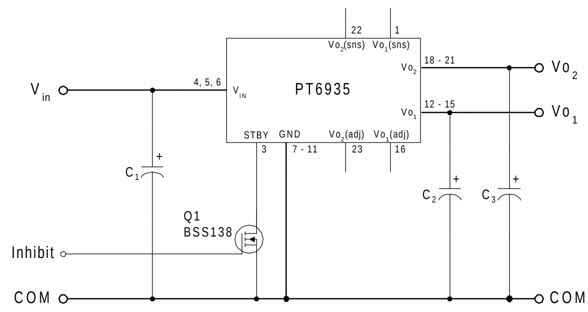
Table 1 Standby Control Parameters [1, 2]

Parameter	Min	Max
Enable (V_{IH})	—	Open circuit
Disable (V_{IL})	–0.1V	0.4V [1]
V_{STBY} (open circuit)	12.6V [2]	15V
I_{STBY} (I_{IL})	—	–0.5mA

Notes:

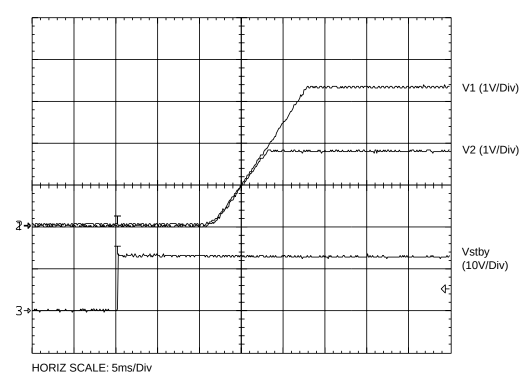
1. The standby control input is <u>*Not*</u> compatible with TTL or other devices that incorporate a totem-pole output drive. Use only a true open-collector device, preferably a discrete bipolar transistor (or MOSFET). To ensure the regulator output is disabled, the control pin must be pulled to less than 0.4Vdc with a low-level 0.5mA sink to ground.
2. The standby control input <u>requires no external pull-up resistor</u>. The open-circuit voltage of the STBY* pin is typically 12.6V.
3. When the regulator output is disabled the current drawn from the input source is typically reduced to 7mA.

Figure 1



Turn-On Time: Turning Q_1 in Figure 1 off removes the low-voltage signal at pin 3 and enables the PT6935 regulator. Following a delay of about 15ms, Vo_1 and Vo_2 rise together until the lower voltage, Vo_2, reaches its set output. Vo_1 continues to rise until both outputs reach full regulation voltage. The total power-up time is less than 30ms, and is relatively independent of load, temperature, and output capacitance. Figure 2 shows waveforms of the output voltages, Vo_1 and Vo_2, for a PT6937 (3.3V/1.8V). The turn-off of Q_1 corresponds to the rise in V_{STBY}. The waveforms were measured with a 5V input voltage, and with resistive loads of 4.5A and 1.9A at the Vo_1 and Vo_2 outputs respectively.

Figure 2



PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
PT6935A	ACTIVE	SIP MOD ULE	ELG	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6935C	ACTIVE	SIP MOD ULE	ELH	23	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS
PT6935N	ACTIVE	SIP MOD ULE	ELF	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6936A	ACTIVE	SIP MOD ULE	ELG	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6936C	ACTIVE	SIP MOD ULE	ELH	23	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS
PT6936N	ACTIVE	SIP MOD ULE	ELF	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6937A	ACTIVE	SIP MOD ULE	ELG	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6937C	ACTIVE	SIP MOD ULE	ELH	23	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS
PT6937N	ACTIVE	SIP MOD ULE	ELF	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6938C	ACTIVE	SIP MOD ULE	ELH	23	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS
PT6938N	ACTIVE	SIP MOD ULE	ELF	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6939A	ACTIVE	SIP MOD ULE	ELG	23	10	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6939C	ACTIVE	SIP MOD ULE	ELH	23	10	Pb-Free (RoHS)	Call TI	Level-3-215C-168HRS

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Clocks and Timers	www.ti.com/clocks	Digital Control	www.ti.com/digitalcontrol
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265